Small Business Innovation Research/Small Business Tech Transfer

Accident Tolerant Reactor Shutdown for NTP Systems, Phase II

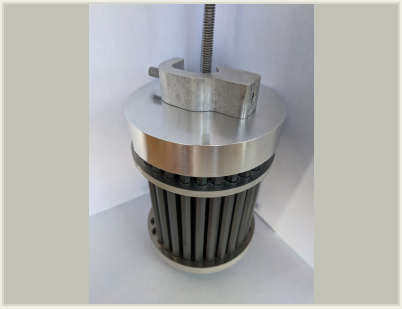
Completed Technology Project (2017 - 2019)

Project Introduction

In brief, USNC's accident submersion safe drums are control drums where a small amount of fuel is added opposite to the neutron absorber and the drums impinge on the active core to substantially increase the shutdown criticality margin of the control drums. Phase 1 results indicate that the shutdown criticality margin is more than sufficient to maintain sub-criticality in the worst-case water submersion accidents. Key accidents that the accident submersion safe drums address include submersion in freshwater and sand with a stuck drum in the full-on position and submersion in water and wet sand with reflector loss. This SBIR will develop the submersion safe reactor shutdown system for Nuclear Thermal Propulsion (NTP) identified in the Phase 1. Remaining subcritical during a during water submersion accident is a design requirement for NTP systems. As of now, all thermal spectrum NTP concepts (including LEU NTP systems) fail to remain subcritical during water submersion and thus are not water submersion safe. USNC's submersion safe control drums enable thermal spectrum NTP systems to remain subcritical during water submersion accidents. Key tasks that will be completed include: 1.Develop a detailed integrated thermal-mechanical and neutronic design of the control drums. 2.Design a power cycle and coolant paths that adequately remove heat from the submersion safe drums while minimizing complexity of the NTP system. 3.Demonstrate the Submersion safe control drum technology in a prototypical reactor experiment and raise the technology's TRL up to 4/5. 4.Deliver a set of NTP system point designs that showcase the full implementation of the drums integrated into a realistic NTP system.

Anticipated Benefits

NTP has great promise in spreading human presence to Mars and other locations beyond low earth orbit. USNC's submersion safe control systems will address key needs in NTP development to make NTP a viable technology to fulfill NASA human exploration needs. USNC's work directly aligns with the NASA Technological Roadmap 2015 "TA 2: In-Space Propulsion Technologies: 2.2.3 Thermal Propulsion" . Currently, NTP and USNC's submersion safe reactor shutdown technology are being investigated for a human Mars Mission in the 2030s time frame, but NTP also has application for many other applications beyond low earth such as lunar exploration architectures and robotic missions into deep space. In the near term USNC's technology will be able to support NTP development efforts by providing the research tools and insight required to understand water submersion accidents in LEU-NTP systems. Before the Phase 1, little work had been conducted on the water submersion in LEU NTP systems and a great deal was learned. After Phase 2, USNC will have a much greater understanding and modeling capabilities that will assist in NASA NTP development efforts. Beyond NTP the technology and expertise that USNC is building has application to small nuclear systems for surface power and science missions.The market for NTP systems and their supporting technologies extend beyond NASA with numerous potential



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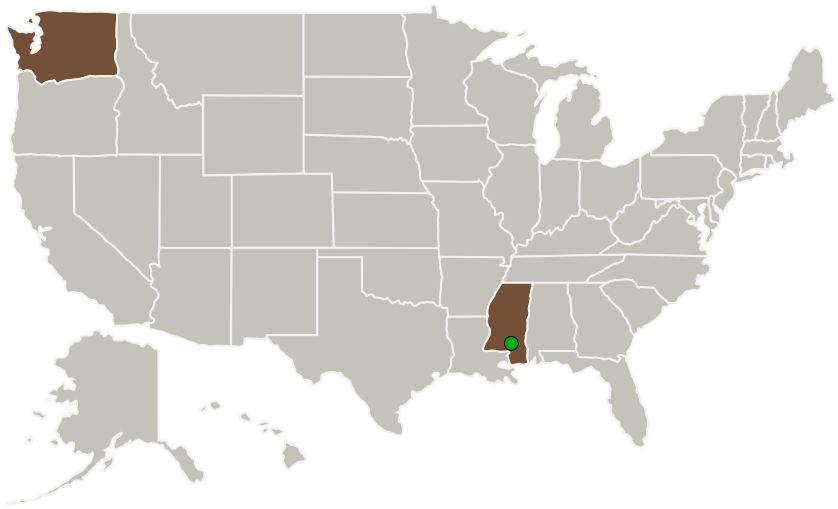
customers in private industry and defense field. NTP is a game changing technology and it is difficult to quantify this non-NASA market but it has the potential to be very large. USNC is pursuing earth based mobile reactors and small modular reactors. These reactors are different than traditional reactors as they can be shipped in whole or modular sections. In shipment of these reactors it is essential to ensure that they are subcritical during water submersion (much like space reactors). The technology developed in this SBIR may have application in addressing water submersion in these earth-based reactors. In addition, a number of other companies are trying to bring mobile or small modular reactors to the market and the novel technology developed in this SBIR might find a market here. The market potential for advanced reactors is several billion dollars and approximately 40 U.S. companies are trying to bring advanced nuclear technology to the market backed by total of more than 1.3 billion dollars of private investment. USNC's submersion safe control technology can address the needs of this emerging market.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Ultra Safe Nuclear Corporation	Lead Organization	Industry	Seattle, Washington
Stennis Space Center(SSC)	Supporting Organization	NASA Center	Stennis Space Center, Mississippi

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Ultra Safe Nuclear Corporation

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

Carlos Torrez

Project Managers:

Larry Dequay
Thomas M Stanley

Principal Investigator:

Paolo F Venneri

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Completed Technology Project (2017 - 2019)

Primary U.S. Work Locations	
Mississippi	Washington

Project Transitions

April 2017: Project Start

July 2019: Closed out

Closeout Documentation:

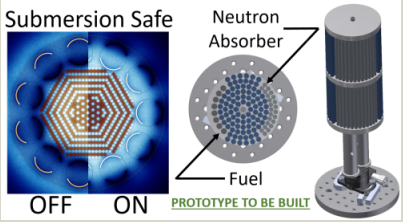
- Final Summary Chart*(https://techport.nasa.gov/file/140912)*

July 2019: Closed out

Closeout Documentation:

- Final Summary Chart PDF*(https://techport.nasa.gov/file/140911)*

Images

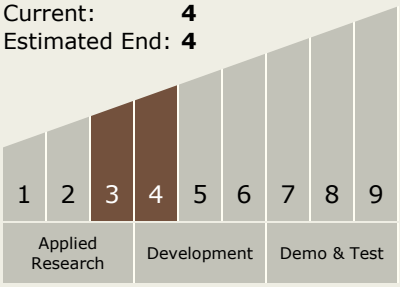


Briefing Chart Image
Accident Tolerant Reactor Shutdown for NTP Systems, Phase II Briefing Chart Image *(https://techport.nasa.gov/image/131599)*

Final Summary Chart Image
Accident Tolerant Reactor Shutdown for NTP Systems, Phase II
(https://techport.nasa.gov/image/131777)

Technology Maturity (TRL)

Start: **3**
Current: **4**
Estimated End: **4**



Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System